Feed Study for Wideband Millimeter-wave Luneburg Lens

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The Luneburg lens (LL) is a dielectric spherical lens with a gradient profile of refractive index derived and implemented such that the aberrations are greatly reduced. Due to the spherical symmetry of the LL, a plane wave normally incident from any direction on the lens will be focused to the focal point on the opposite side of the lens. With multiple switchable feeds, a beam can be steered without any degradation of beam quality, which is advantageous compared to regular planar phased arrays. In this work, we focus on the use of a LL as a wideband millimeter-wave beamformer which does not require an overly robust mechanical structure, typically needed for many reflector antennas, nor does it require the complex phase network needed for a phased array.

A comparative study of low and high-power feeds used to excite a wideband millimeter-wave LL is performed. The feed types include dual and quad-ridge horns, Vivaldi, and spiral antennas. The frequency range of interest is from 18 to 45 GHz (2.5:1 bandwidth); therefore the typically used open ended waveguides are excluded from consideration. An antenna feed with a frequency stable phase center position is critically important for the proper LL operation, because displacement of the phase center position from the lens focal point reduces directivity and enhances side lobe level of a beam. In addition, an array (manifold) of antenna feeds is considered around the LL to demonstrate the directive beamforming capabilities of the LL antenna. The effect of coupling between the antenna feeds on the phase center position variation over the frequency band is evaluated. In addition, the effect of finite and often very small number of dielectric layers in practical LLs on system performance is taken into account.